National Air Quality Forecast Capability: Progress in 2010

September 15, 2010

Ivanka Stajner

Outline

Background on NAQFC

Progress in 2010

- *Operational products*
- *Experimental products*
- *Developmental testing*

Coordination with Partners

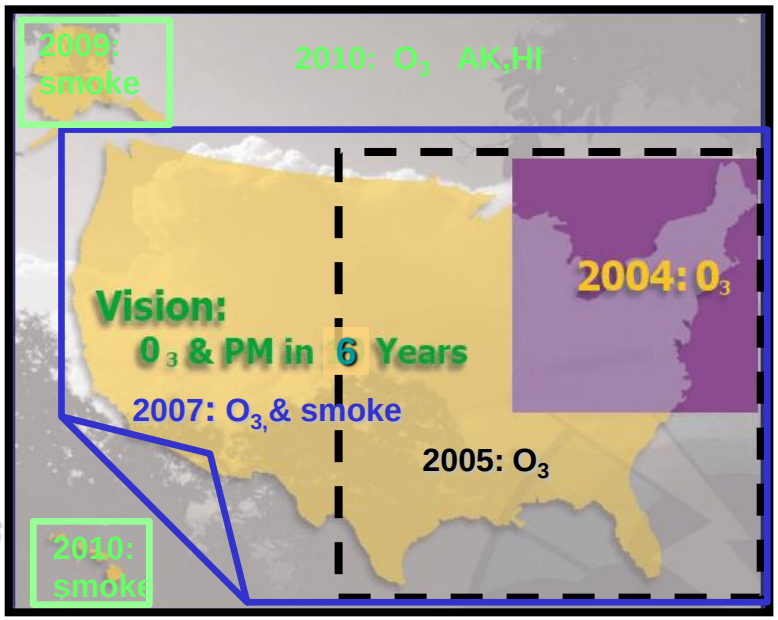
Looking Ahead

National Air Quality Forecast Capability
Current and Planned Capabilities, 9/10

- Improving the basis for AQ alerts
- Providing AQ information for people at risk

FY10 Prediction Capabilities:

- **Operations:**
  Ozone, expanded from EUS to CONUS, 9/07
  Smoke implemented over CONUS (3/07),
  AK (9/09), and HI (2/10)
- **Experimental testing:**
  Ozone over AK and HI
  Dust predictions over CONUS
  Ozone upgrades
- **Developmental testing:**
  *Components for **particulate matter** (PM) forecasts*
  Ozone upgrades



Near-term Operational Targets:

- Ozone coverage extended Nationwide

Longer range:

- Quantitative $PM_{2.5}$ prediction
- Extend air quality forecast range to 48-72 hours
- Include broader range of significant pollutants, e.g. SO_2

National Air Quality Forecast Capability
End-to-End Operational Capability

Model Components: Linked numerical prediction system

Operationally integrated on NCEP's supercomputer

- *NCEP mesoscale NWP: WRF-NMM*
- *NOAA/EPA community model for AQ: CMAQ*

Observational Input:

- *NWS weather observations; NESDIS fire locations*
- *EPA emissions inventory*

Gridded forecast guidance products

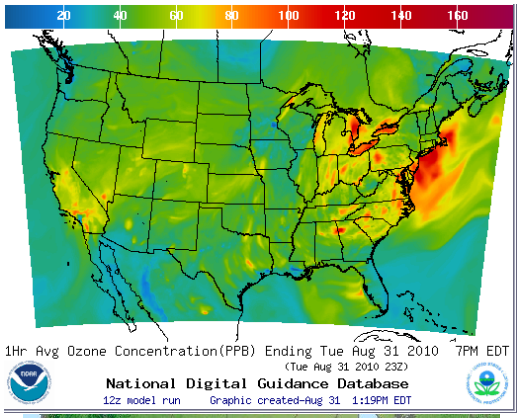
- *On NWS servers: www.weather.gov/aq and ftp-servers*
- *On EPA servers*
- *Updated 2x daily*

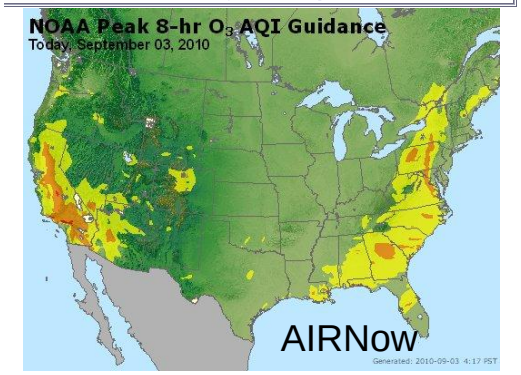
Verification basis, near-real time:

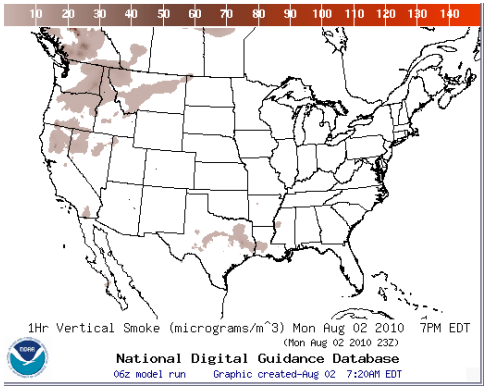
- *Ground-level AIRNow observations*
- *Satellite smoke observations*

Customer outreach/feedback

- *State & Local AQ forecasters coordinated with EPA*
- *Public and Private Sector AQ constituents*







Progress in 2010

Towards ozone, smoke nationwide, dust testing

Ozone Upgrades: Targeting Expanded Forecast Guidance for Alaska and Hawaii domain in NWS operations

- *Operations, 2010: Updates for CONUS (emissions), new 1, 8-hour daily maximum products,*
- *Experimental Testing: CB-05 chemical mechanism, experimental AK and HI ozone predictions*
- *Developmental testing: changing boundary conditions, dry deposition, PBL in CB-05*

Smoke: Implemented into Operations 3/1/07 over CONUS

- *Operations: CONUS Dec 2008 upgrades. AK (9/29/09) and HI (2/23/10) smoke implemented*
- *Developmental testing: Improvements to verification*

Aerosols: Developmental testing providing comprehensive dataset for diagnostic evaluations. (CONUS)

- *CMAQ (aerosol option), testing CB-05 chemical mechanism*
  - Qualitative; summertime underprediction consistent with missing source inputs
- *Dust and smoke inputs: testing dust contributions to PM2.5 from global sources*
  - Real-time testing of combining smoke inputs with CMAQ-aerosol
- *Testing prediction of experimental prediction of dust from CONUS sources*
- *Developing prototype for assimilation of surface PM2.5 measurements*
- *R&D efforts continuing in chemical data assimilation, real-time emissions sources, advanced chemical mechanisms*

Updates in 2010
Operational Products

NAM update (December, 2008)

- **Model Parameterizations:** PBL/turbulence schemes and vertical diffusion applied to separate water species, absorption coefficients for water and ice doubled in radiation scheme, changes to land-surface physics under snow coverage
- **Data assimilation:** Upgraded GSI with a new version of radiative transfer, more satellite and aircraft obs
- **Initialization:** Background for the first analysis comes from the global system (GDAS)

Ozone Predictions: Emissions Updates (May, 2010)

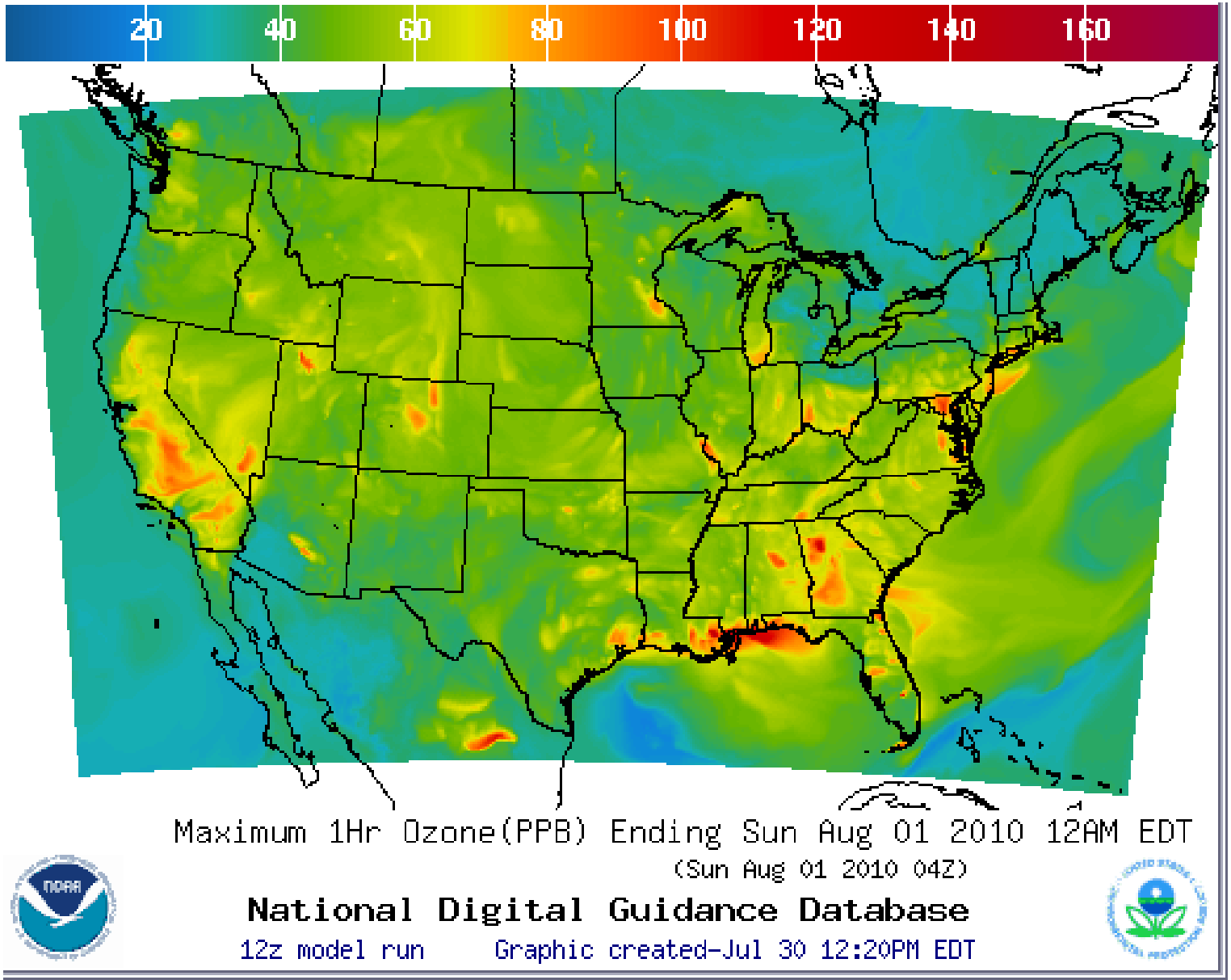
- **Point, area and mobile source emissions: updated based on NEI (2005) and projected for the current year.**
  - *EPA Office of Transportation and Air Quality on-road emissions estimates*
  - *EGU sources: 2008 CEM data projected for 2010.*
- **Biogenic sources: BEIS 3.13**

Smoke:

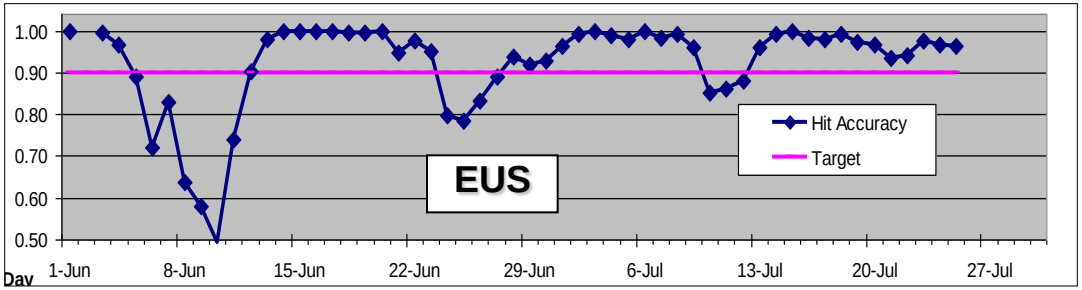
- Implemented operational prediction for Hawaii February 2010
  - Finer aggregation grid of 5 km for smoke sources over HI

Operational CONUS Ozone

Daily maximum of 1h and 8h averages: maps, point value tables and binary data files



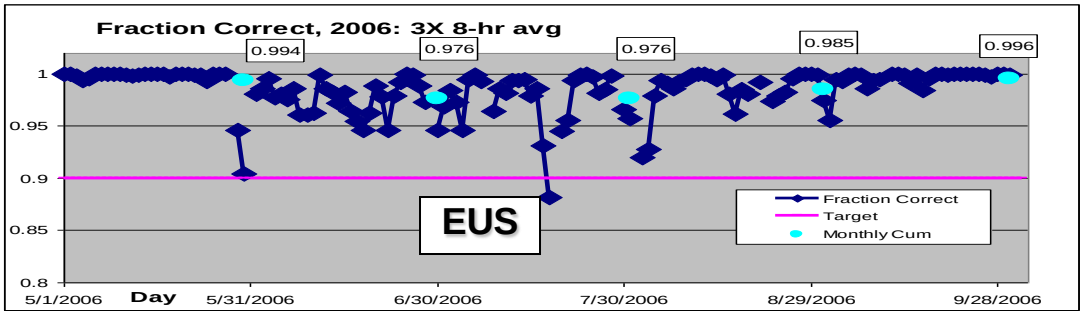
Progress from 2005 to 2008:
Ozone Prediction Summary Verification



2005

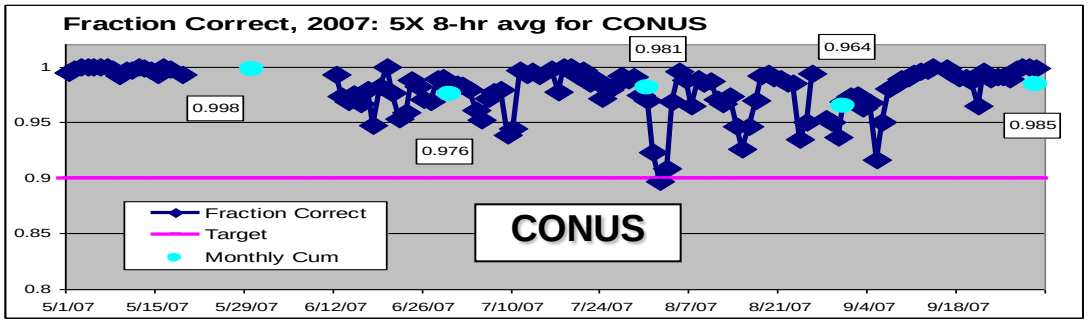
Initial Operational Capability (IOC)

Operational, NE US Domain



2006 **Operational**

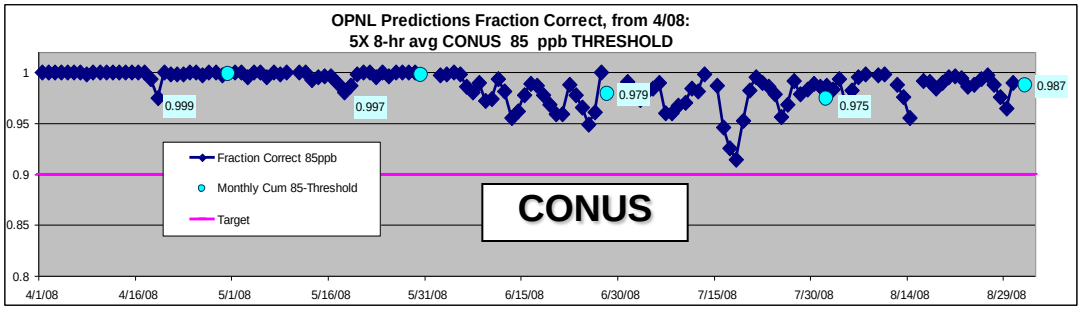
Operational, Eastern US



2007 **Experimental**

Experimental, Contiguous US

Approved 9/07 to replace Eastern US config in operations

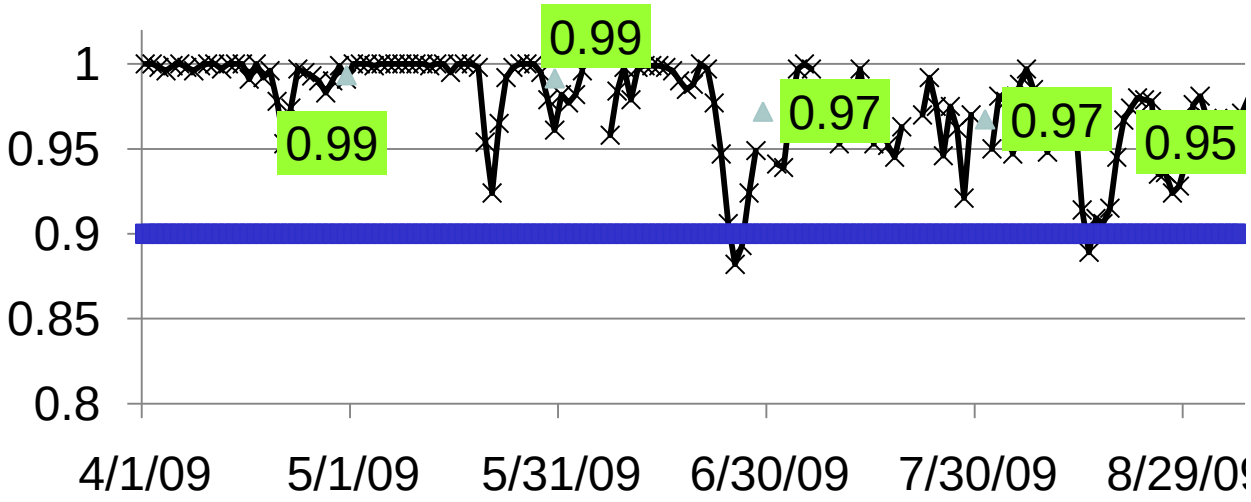


2008 **Operational**

CONUS, wrt 85ppb Threshold

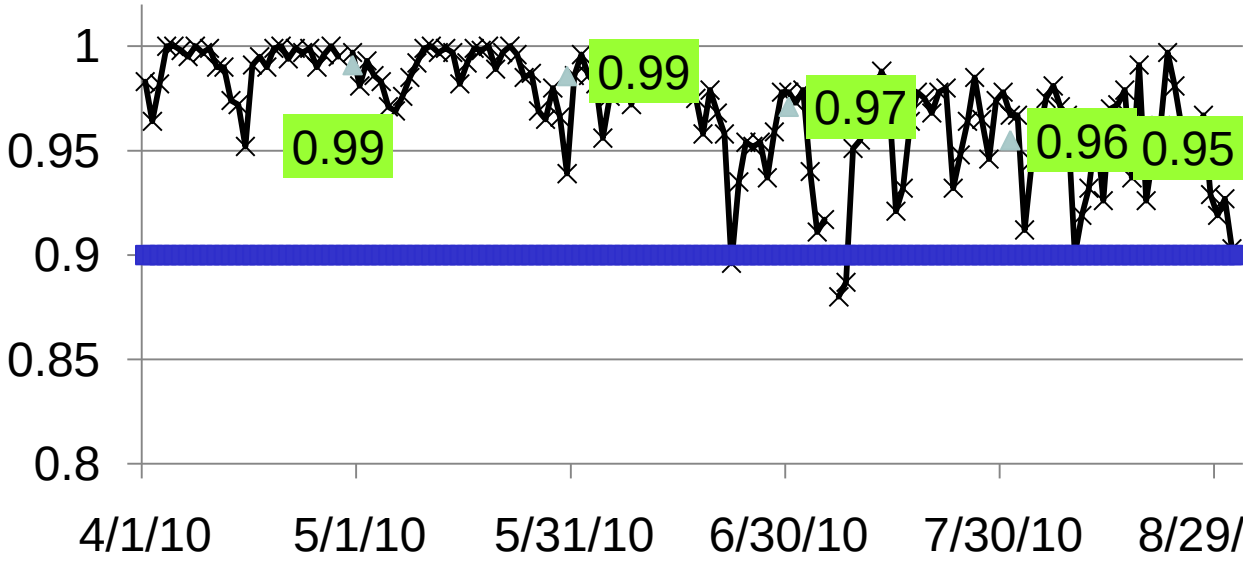
Progress from 2009 to 2010:

CONUS O_3 Prediction Summary Verification



2009 **Operational**

CONUS, wrt 76ppb Threshold

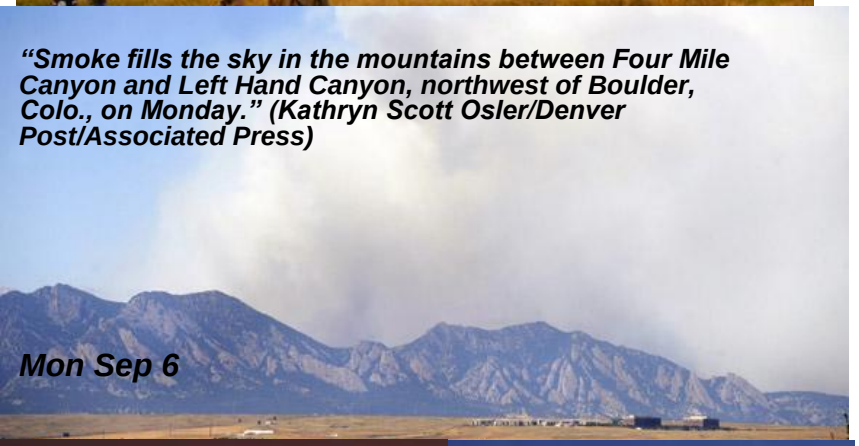


2010 **Operational**

CONUS, wrt 76ppb Threshold

Colorado fire, 9/7/2010

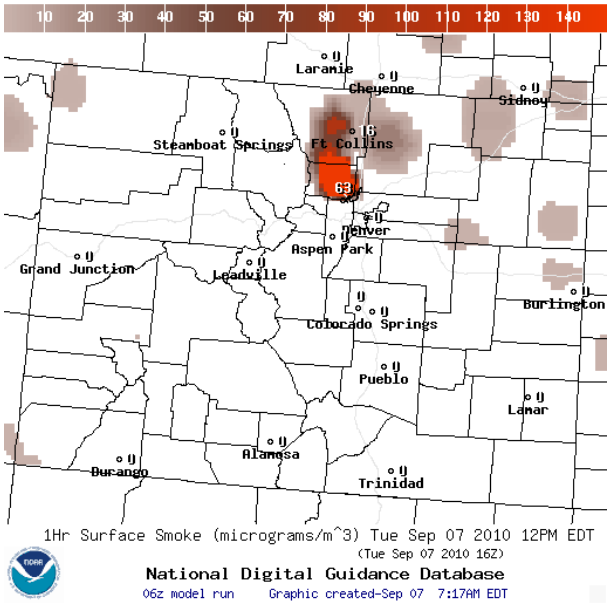
"Smoke plume from a wildland fire burning in the Four Mile Canyon area just west of Boulder Colo. on Monday, Sept. 6, 2010. High winds pushed the smoke and ash eastward over the Colorado plains."

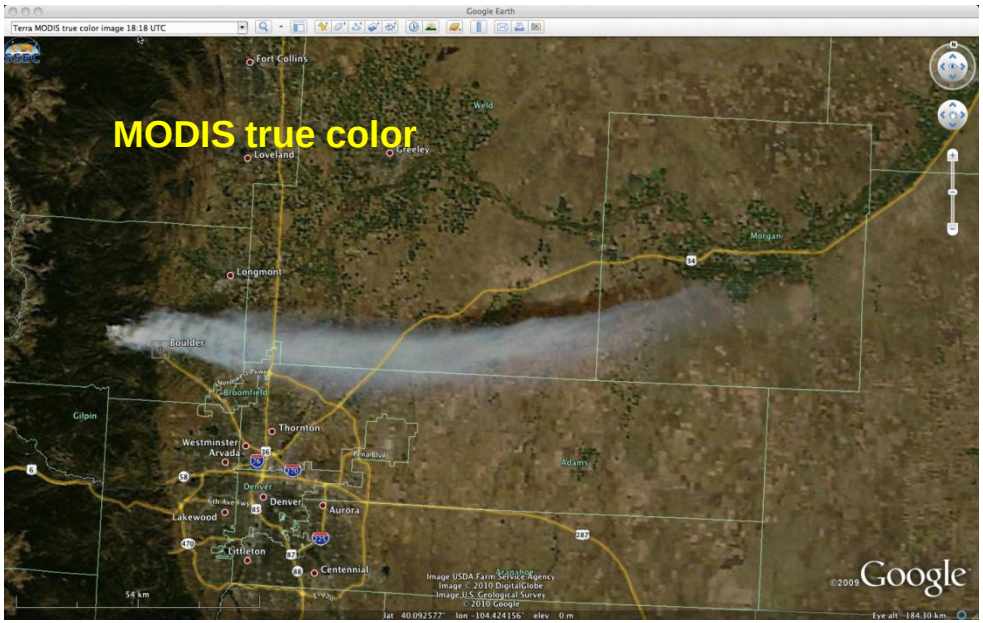


"Smoke fills the sky in the mountains between Four Mile Canyon and Left Hand Canyon, northwest of Boulder, Colo., on Monday." (Kathryn Scott Osler/Denver Post/Associated Press)

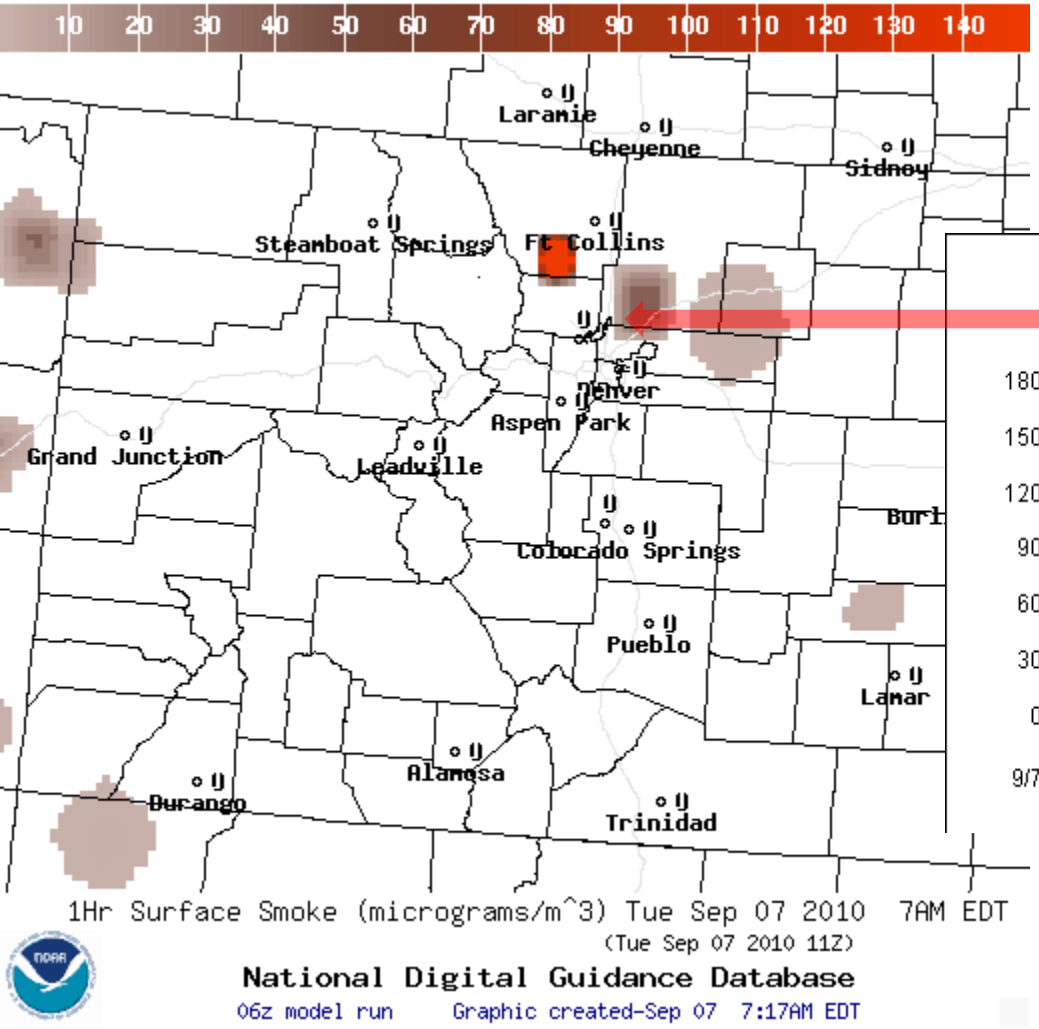
"The blaze broke out Monday morning in Four Mile Canyon northwest of Boulder and rapidly spread across roughly 1,400 hectares. Erratic wind gusts sometimes sent the fire in two directions at once."

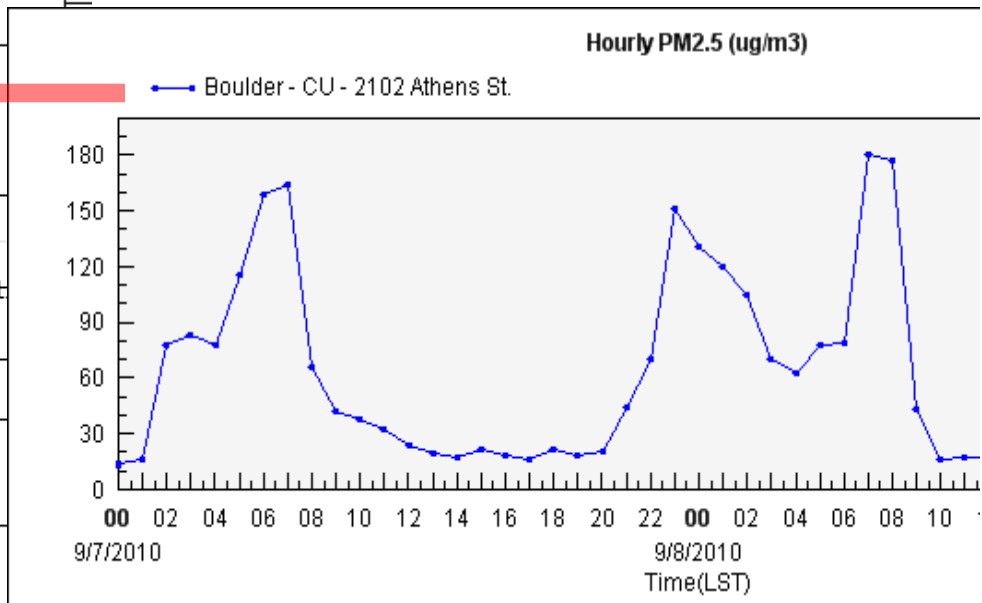
"The 11-square-mile blaze had destroyed at least 92 structures and damaged at least eight others by Tuesday night, Boulder County sheriff's Cmdr. Rick Brough said."





September 7-8, 2010





Real-time Testing, Summer 2010: *Experimental Testing*

Experimental Predictions

Publicly available, real-time

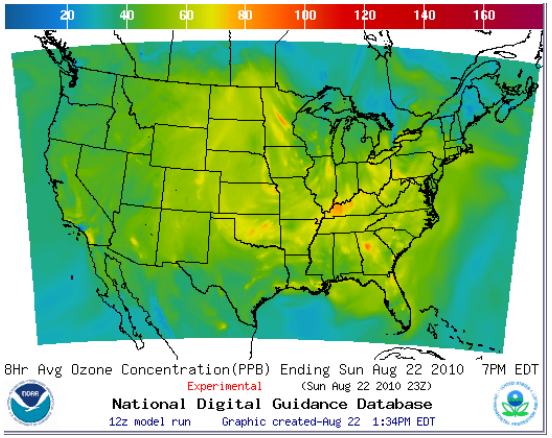
Ozone:

- *CMAQ with advanced gas-phase chemical mechanism CB05*
  - more Volatile Organic Compound (VOC) reactions
  - challenge: more O_3 with CB05
  - regional implications: CONUS, AK, HI

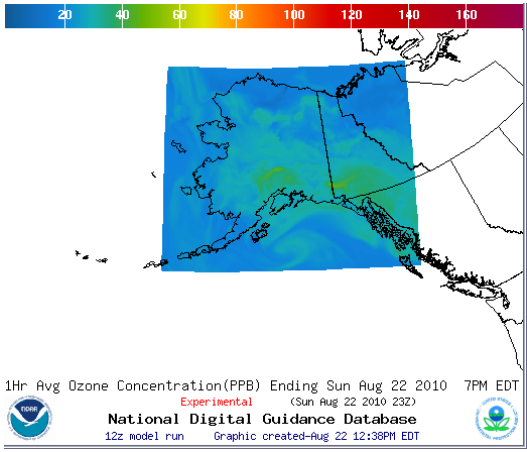
Dust:

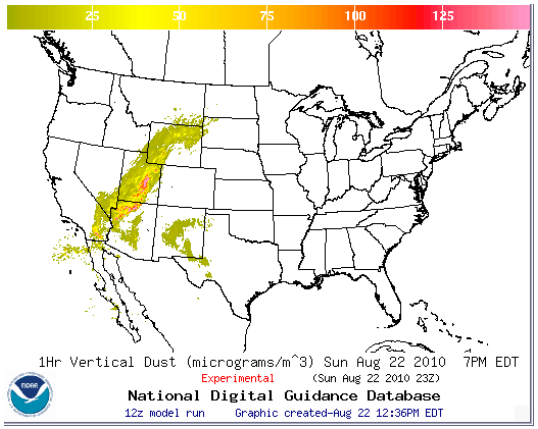
- *Testing over CONUS*

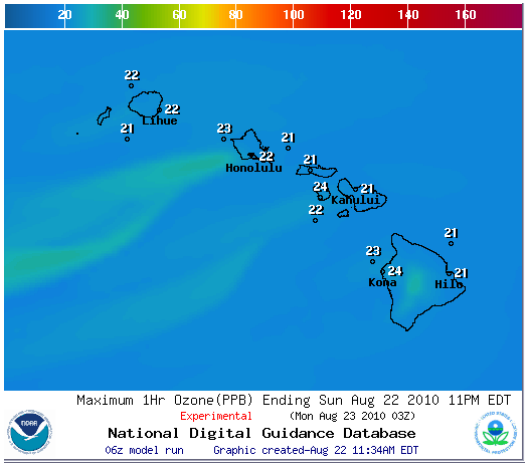
Experimental



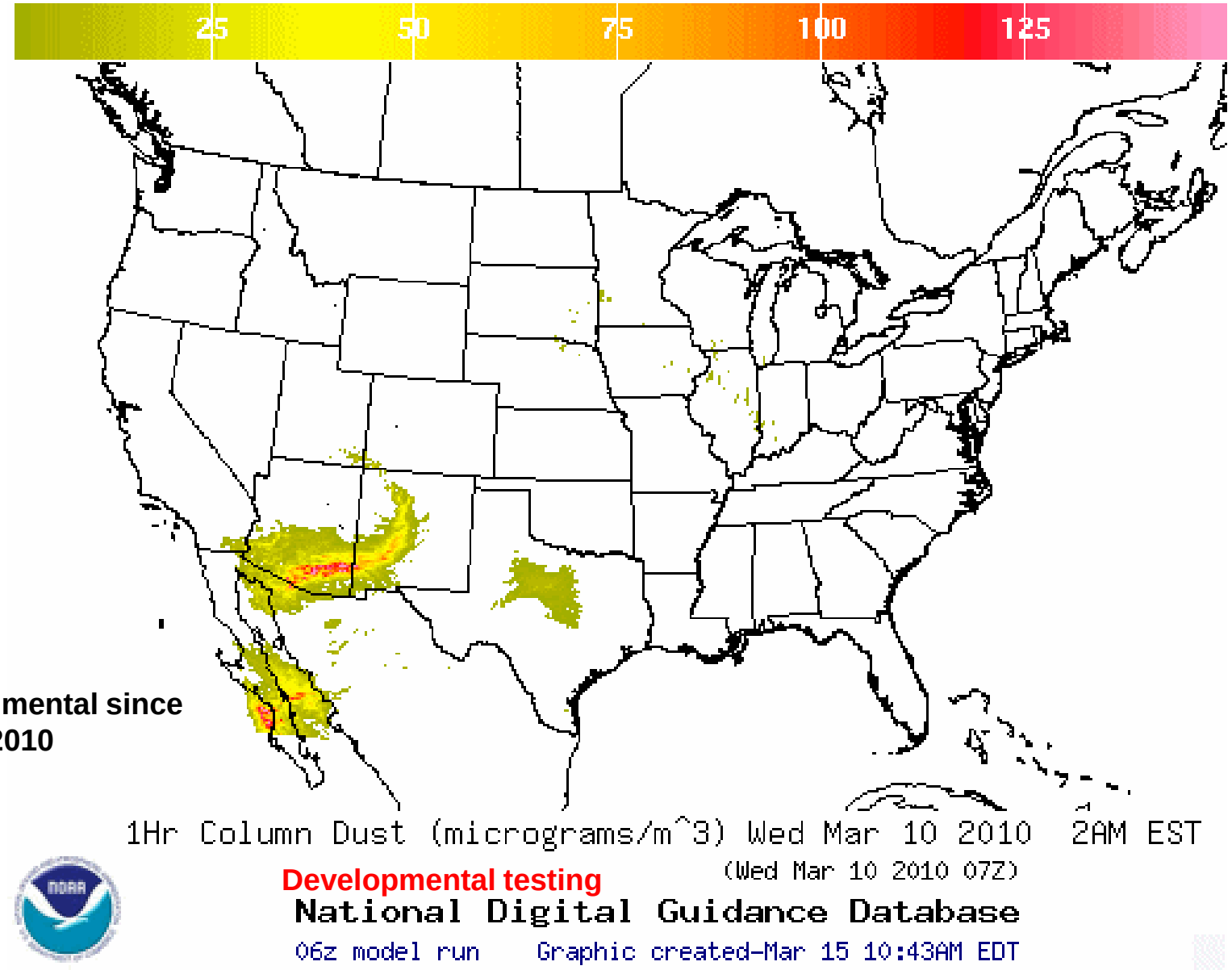
Experimental







Testing of CONUS dust predictions



Experimental since June 2010

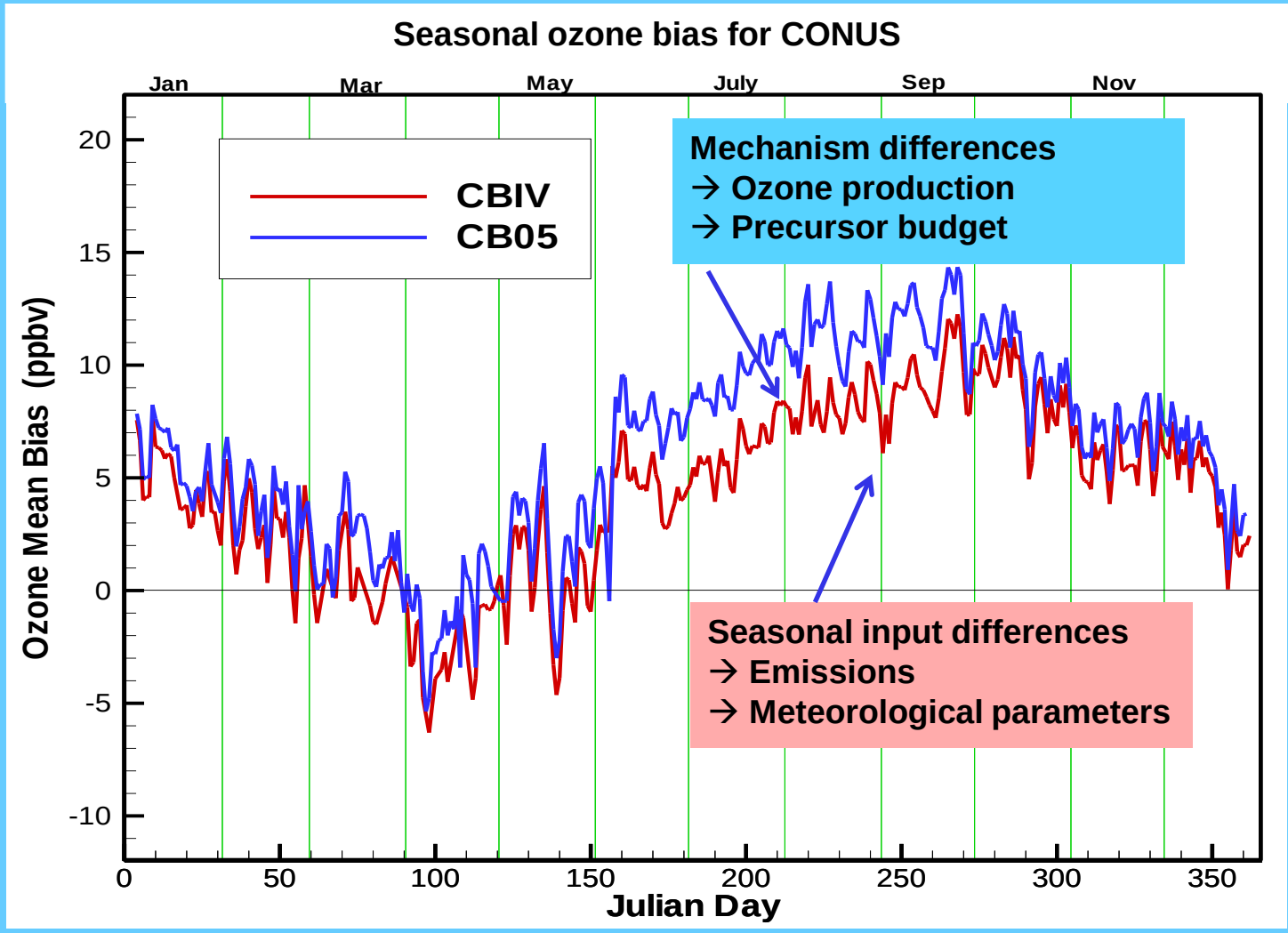
Chemical mechanism sensitivity analysis

Updated CB05 mechanism shows larger biases than CBIV

- Summertime,
- Eastern US.

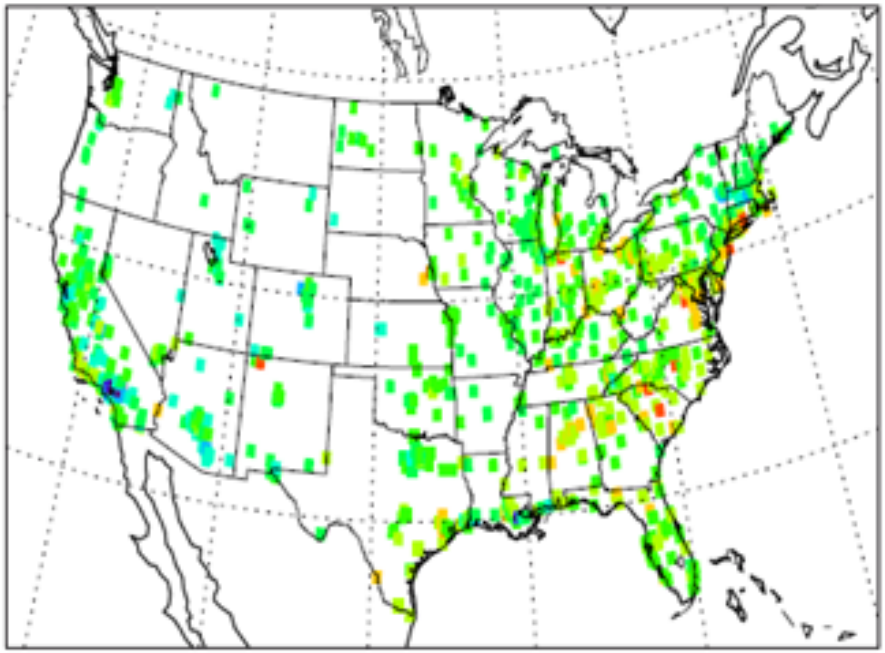
Sensitivity studies in progress:

- Chemical speciation
- Indicator reactions

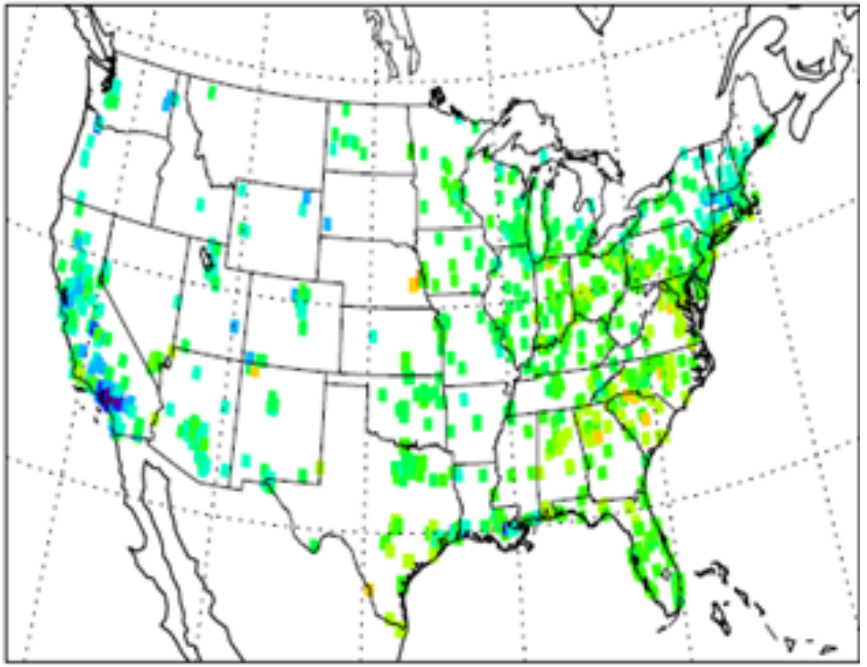


Comparison of CB05 Runs: Base with Combination

Model-minus-AIRNow observations: mean for daytime in August 2009



Base Run, like experimental testing



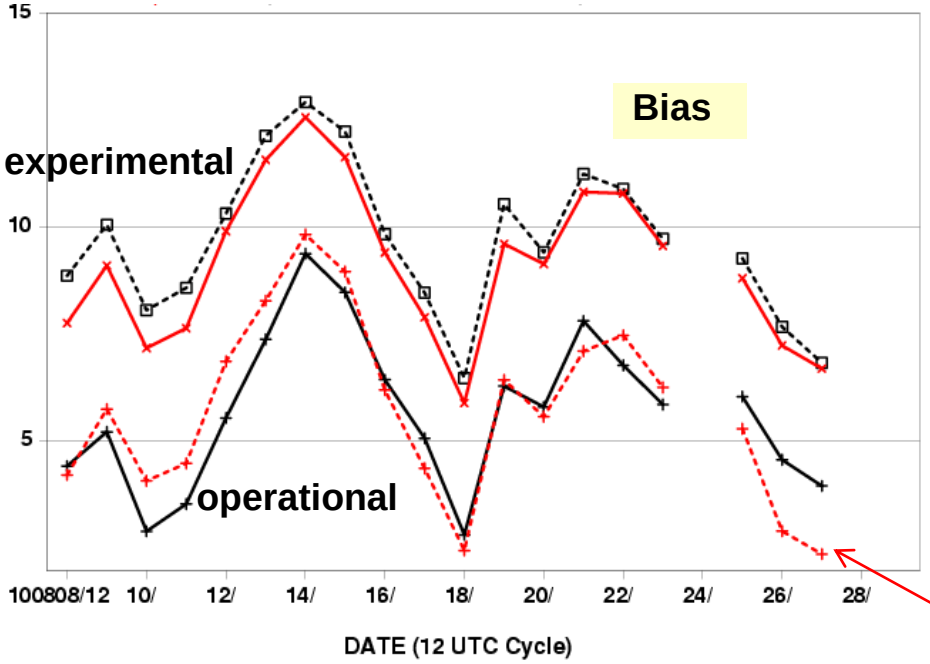
Combination Run:

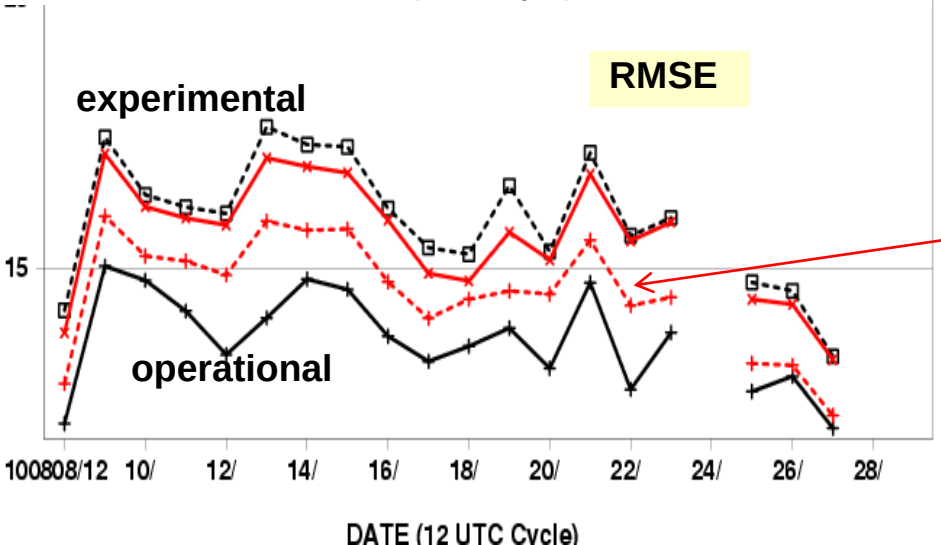
- LBCs,

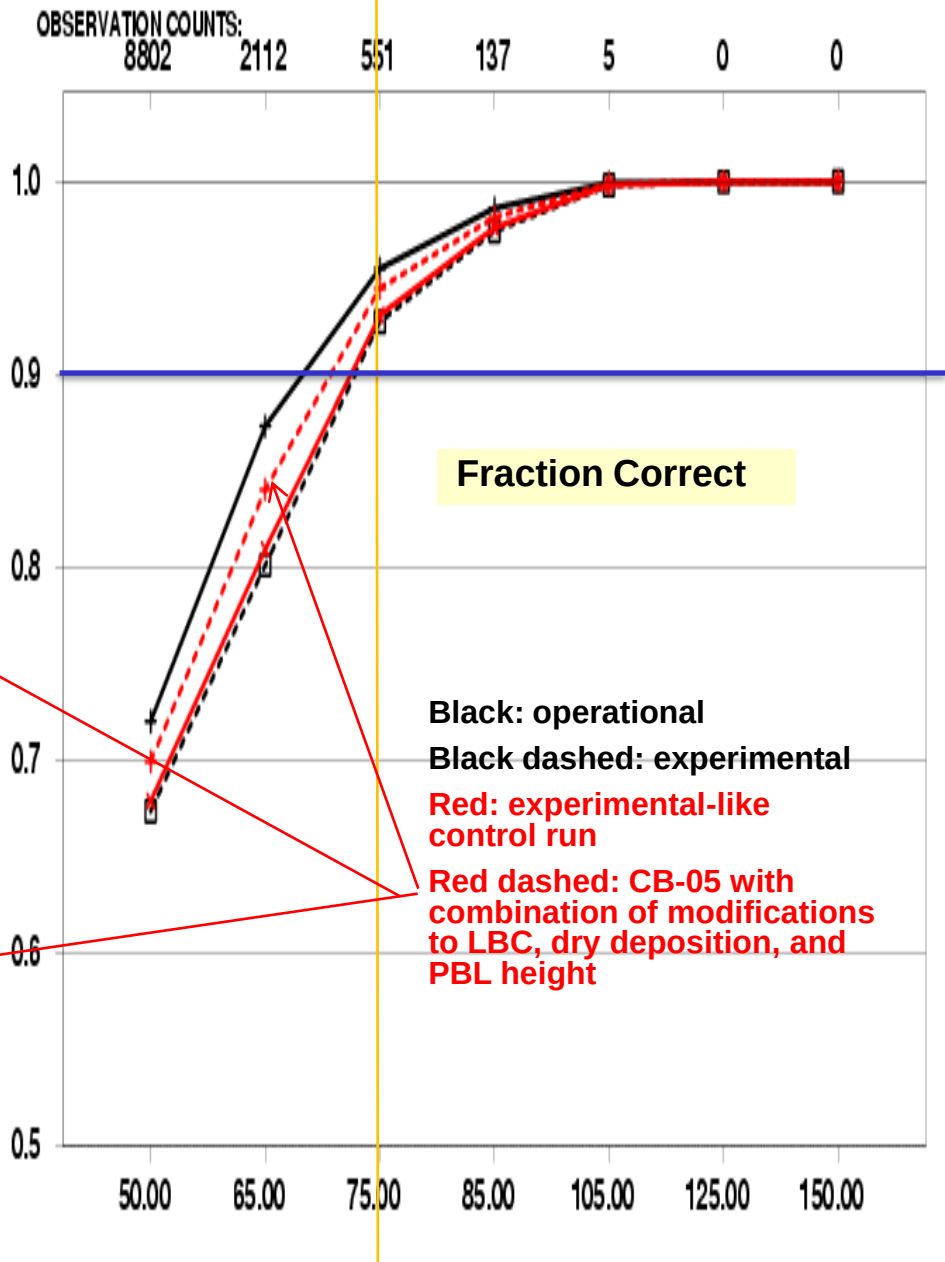
- minimum PBL height,

- dry deposition

Daily 8 hr Max ozone errors for day 2 over CONUS







Developmental predictions, Summer 2010

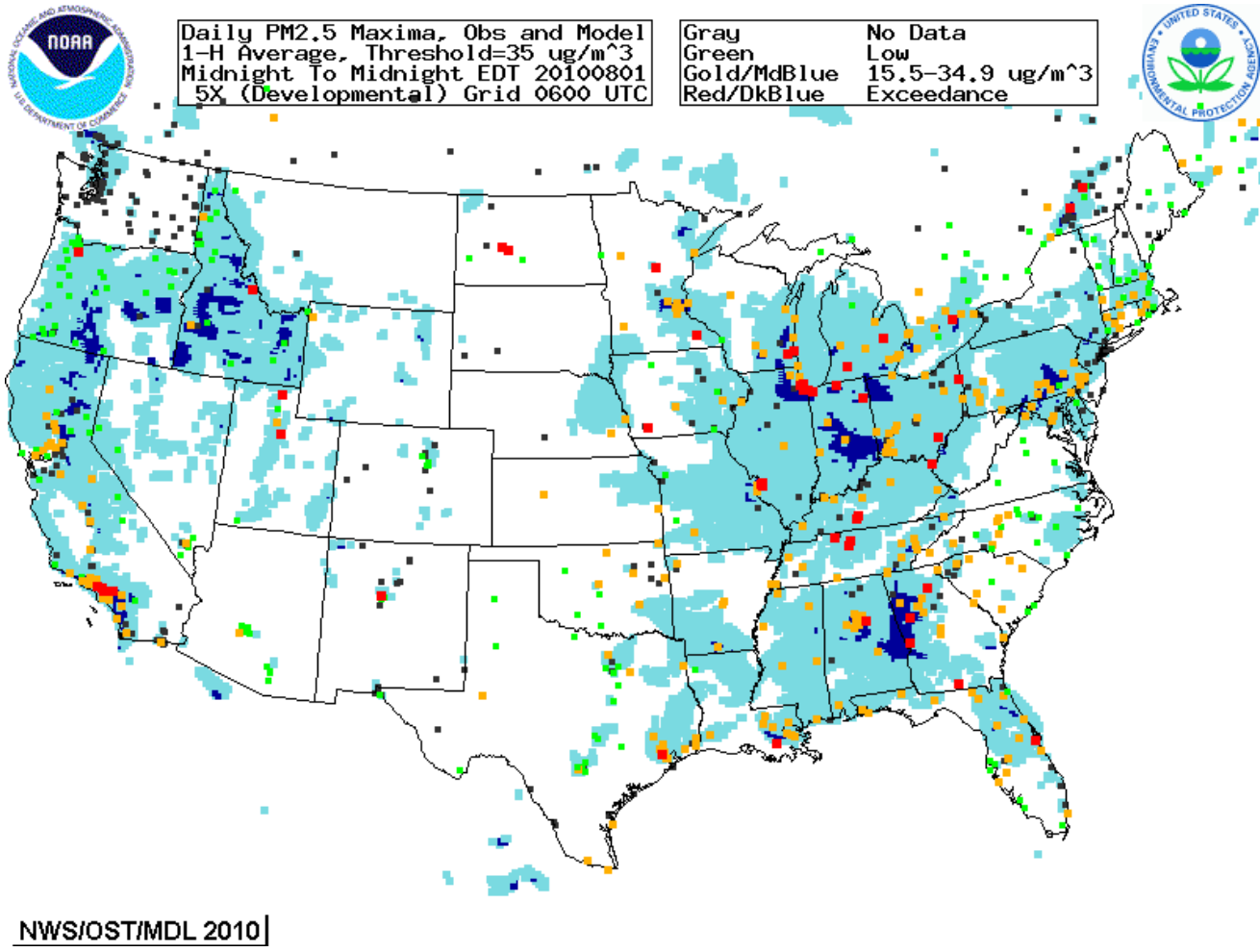
Focus group access only, real-time as resources permit

Aerosols over CONUS

From NEI sources only

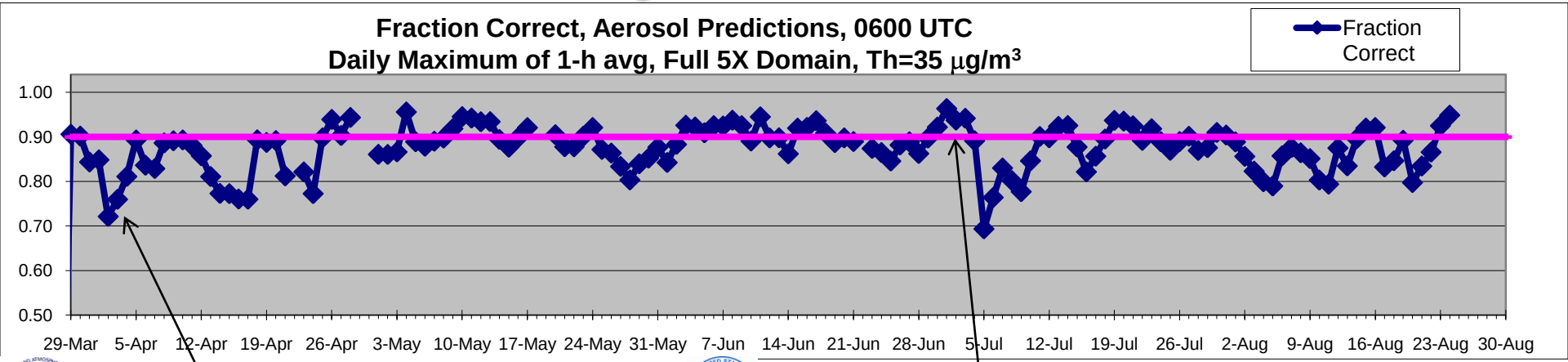
- CMAQ: CB05 gases, AERO-4 aerosols
- sea salt emissions and reactions

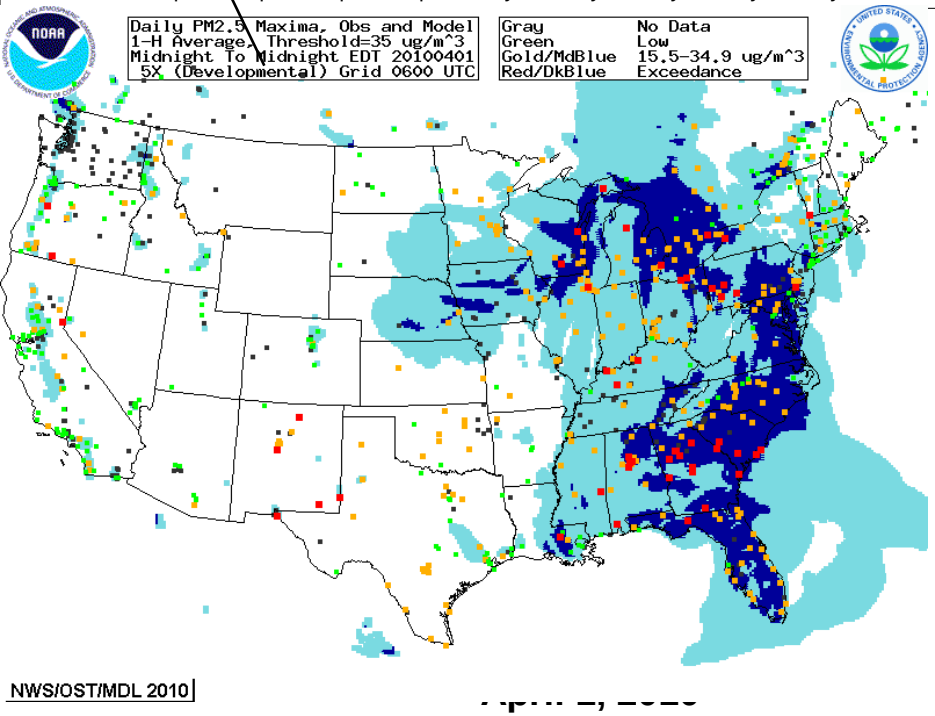
Testing of real-time wildfire smoke emissions in CMAQ

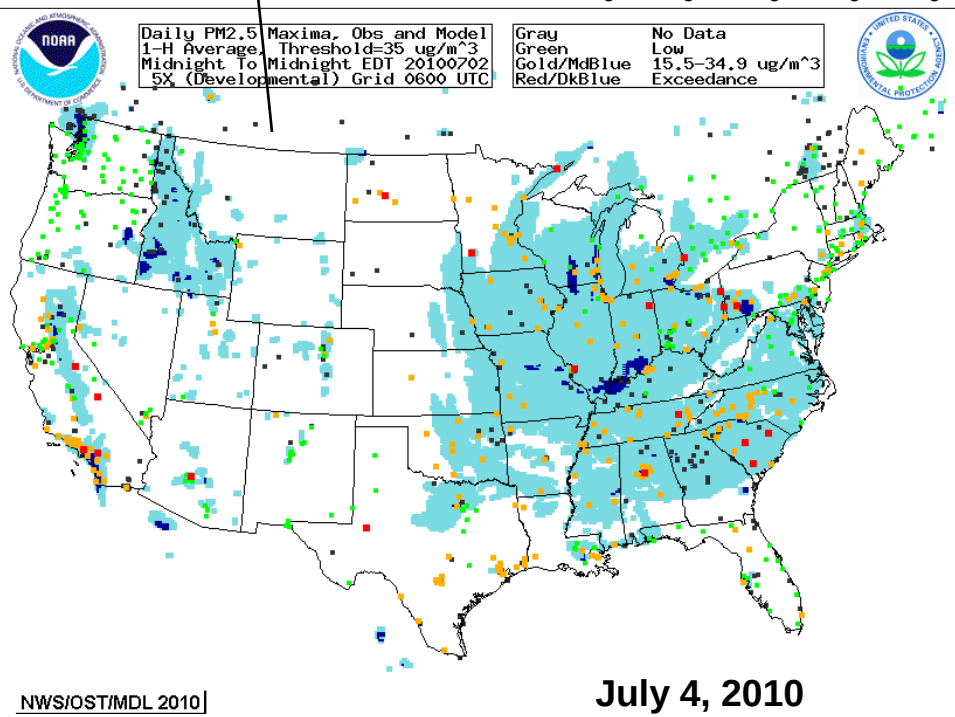


Developmental Aerosol Predictions:

Summary Verification, 2010





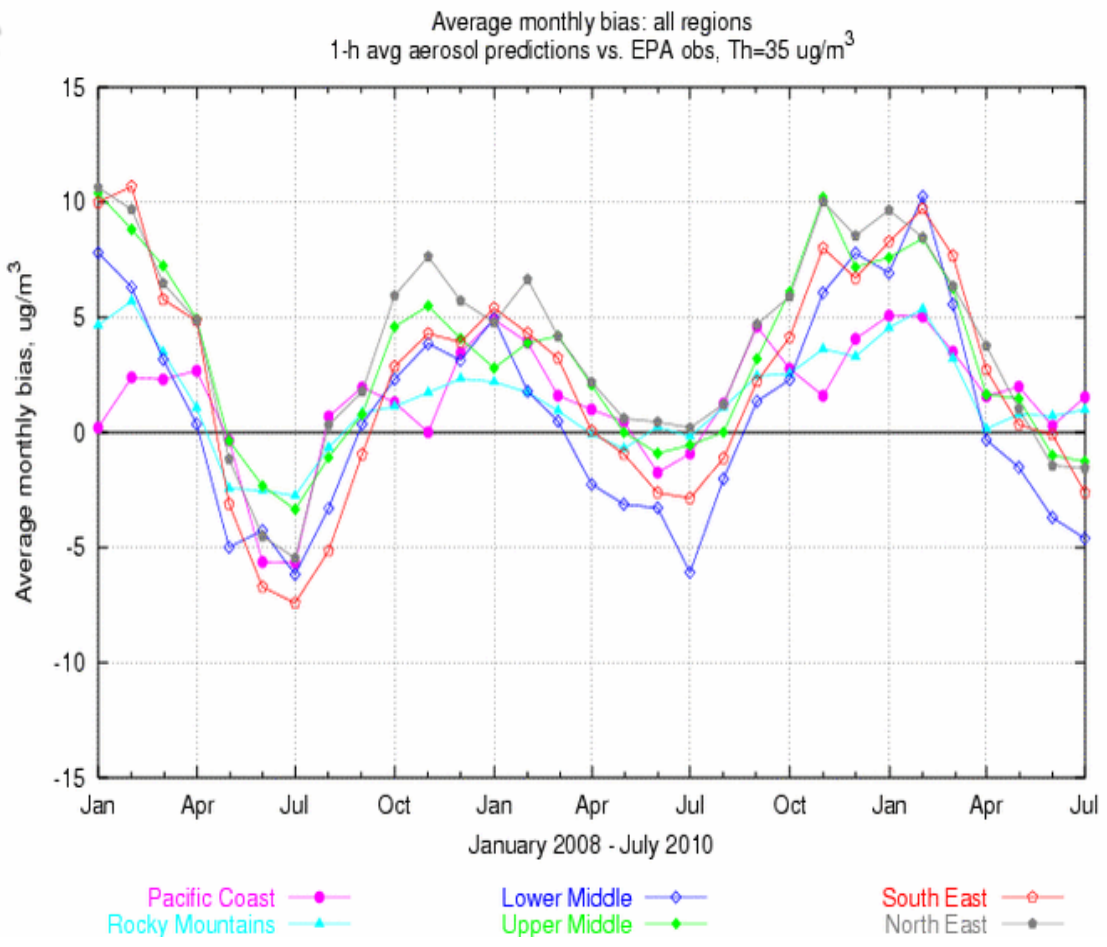


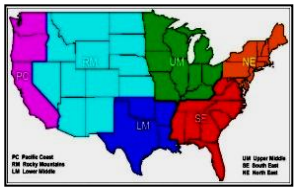
July 4, 2010

Quantitative PM performance

Forecast challenges

- *Aerosol simulation using emission inventories:*
  - Show seasonal bias-- winter, overprediction; summer, underprediction
- *Intermittent sources*
- *Chemical boundary conditions/trans-boundary inputs*





Partnering with AQ Forecasters

http://www.epa.gov/airnow/airaware/

Focus group, State/local AQ forecasters:

- **Participate in real-time developmental testing of new capabilities, e.g. aerosol predictions**
- **Provide feedback on reliability, utility of test products**
- **Local episodes/case studies emphasis**
- **Regular meetings; working together with EPA's AIRNow and NOAA**

Coordination of NWS and AQ Forecasters

Local: NWS WFO forecaster

- **WFO forecasters have reached out to AQ forecasters; available for discussion**
- **Participation in AQ Awareness week**

National level: HPC forecasters

- **Event-driven coordination: NCEP/HPC available to participate in coordination calls to provide regional and/or synoptic weather information/input**
- **AQ forecasters web-drawer, June 1- September 3 www.hpc.ncep.noaa.gov/aqtest/**
  - *Next-day AQ-relevant weather summary*
  - *Displays of ozone, smoke predictions*
  - *Selected NDFD forecasts, graphical products for T, winds, stability*

International level: Canadian AQ forecasters and AQ model developers

  - *NOAA and EC Co-host International workshops on AQ Forecasting Research, Dec 2009, Nov 2010*

Products, domain coverage still expanding

- **NWS and AQ forecaster coordination: growth area**
- ***Feedback essential for refining/improving coordination***

Example feedback

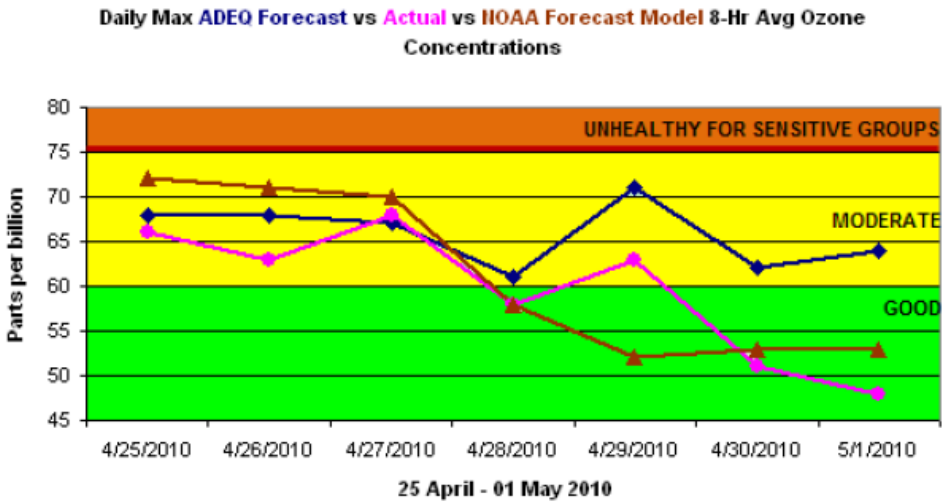
From Christopher Reith, Arizona ADEQ

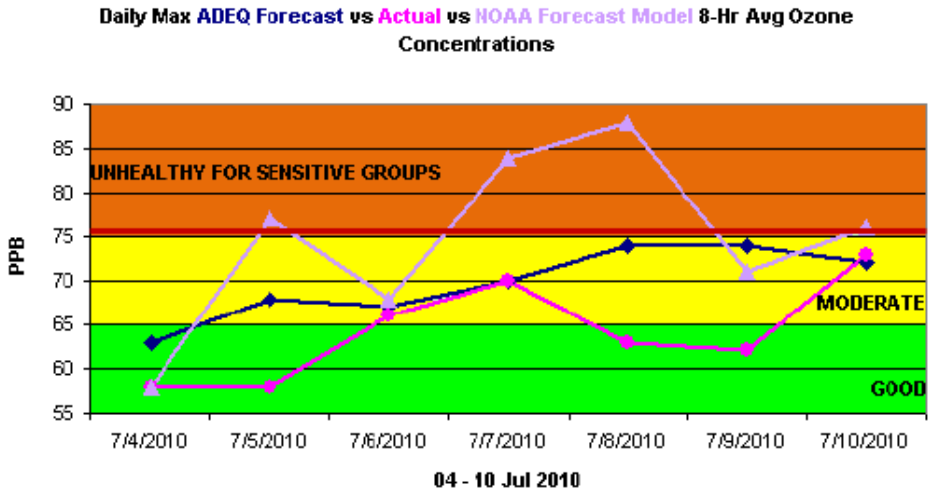
Daily comparison of late-day predictions with Arizona ADEQ forecasts and observations.

*"…wide range of accuracy from the NOAA model...from being **dead-on early in the season to being grossly positively biased during much of the last few weeks**…"*

"…since April 01 there have been seven ozone exceedance days…The NOAA ozone model accurately picked five of the seven which is great; it also predicted 40 exceedance days during the same period which is not so great.

"…In addition, the NOAA model has predicted very high ozone AQI numbers. The highest actual ozone AQI level reached so far this season has been 124; the NOAA model has predicted higher levels than this on 11 of the 40 days including two days above the 150 ppb level…"





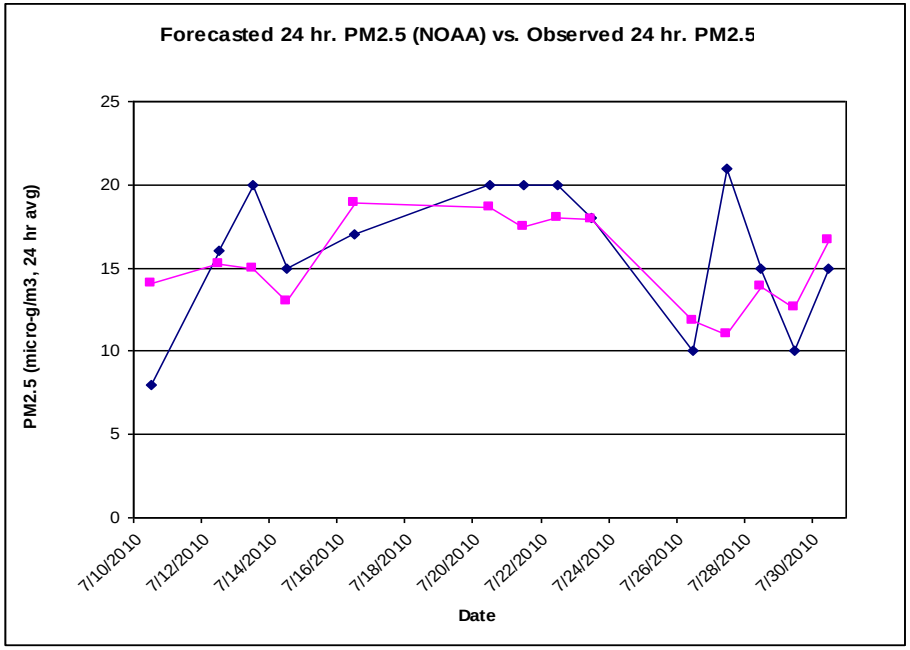
Example Feedback

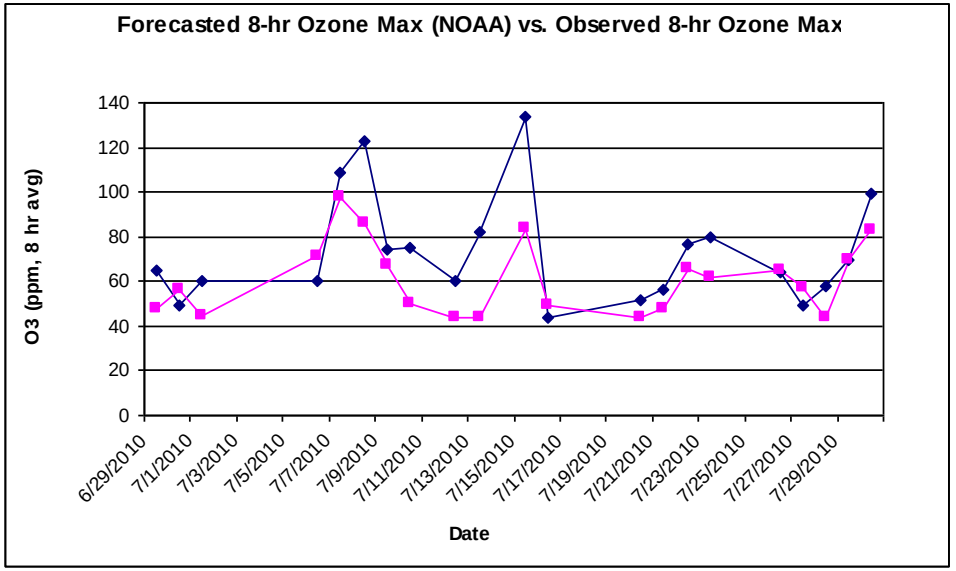
From Nyasha Dunkley, Georgia AQ Forecaster

"…looking at the values, it appears that the NOAA model has a slight tendency to overpredict the 8hr ozone values, as well as PM2.5 (though the PM overprediction is not quite as dramatic as the ozone)…"

"…noticed about the experimental model (as can be seen in the graph), is that although it's overpredicting a fair amount, it seems to be catching the trend in concentrations fairly well (especially considering how much trouble moisture has made forecasting for this season)…"

Looking at June-July data





National AQF Capability:
Next Steps

Product Improvements:

- **Daily Max products for day 1, Verification portal updates**
- **Testing modifications to CB-05 system (LBC, dry deposition, PBL height…)**
- **Closer coupling of AQ with new version of meteorological model, NMM-B; horizontal and vertical resolution, vertical mixing treatment**
- **Update emissions inventory**

Expanding, Improving Ozone forecast guidance (WRF-CMAQ)

- Coverage over 50 states targeted by end of FY10

Experimental testing of dust predictions over CONUS

Development and integration of components for quantitative particulate matter predictions:

- *Assimilation of surface PM2.5 measurements*
- *Objective satellite products for verification (ongoing)*
- *Aerosols predictions from anthropogenic source emissions in inventories: continued development/testing/analysis– testing advanced chemical mechanisms*
- *Further component development, chemical data assimilation, dust, speciated fire emissions, integration of PM components*
- *Target operational implementation for initial PM forecasts, NE US: FY15*

National Air Quality Forecast Capability
Looking Ahead

Nationwide ozone and particulate matter predictions

- ***Expanding ozone & smoke to nationwide coverage, Target: FY10 and***
- ***Begin quantitative particulate matter predictions, Target: FY15***

- **Providing information Nationwide on when/where poor AQ is expected**
- **Reducing losses to life (60,000) each year from poor AQ**
- **Reducing economic losses (>$100B each year) from poor AQ**

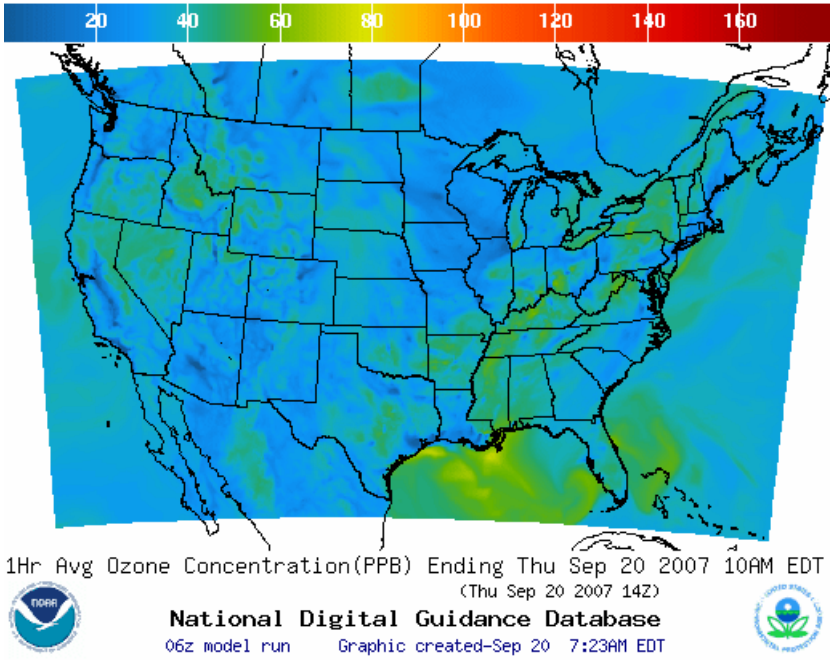
Acknowledgments:
AQF Implementation Team Members

NOAA/NWS/OST	***Tim McClung***	***NAQFC Manager***
NOAA/OAR	***Jim Meagher***	***NOAA AQ Matrix Manager***
NWS/OCWWS	***Jannie Ferrell***	***Outreach, Feedback***
NWS/OPS/TOC	***Cindy Cromwell, Bob Bunge***	***Data Communications***
NWSOST/MDL	***Jerry Gorline, Marc Saccucci, Tim Boyer, Dave Ruth***	***Dev. Verification, NDGD Product Development***
NWS/OST	***Ken Carey, Kyle Wedmark***	***Program Support***
NESDIS/NCDC	***Alan Hall***	***Product Archiving***
NWS/NCEP		
Jeff McQueen, Dr. Youhua Tang, Marina Tsidulko, Jianping Huang		**AQF model interface development, testing, & integration**
***Sarah Lu , Ho-Chun Huang**		**Global data assimilation and feedback testing**
***Brad Ferrier, *Dan Johnson, *Eric Rogers, *Hui-Ya Chuang**		**WRF/NAM coordination**
Geoff Manikin		**Smoke Product testing and integration**
Dan Starostra, Chris Magee		**NCO transition and systems testing**
Robert Kelly, Bob Bodner, Andrew Orrison		**HPC coordination and AQF webdrawer**
NOAA/OAR/ARL		
Daewon Byun, Pius Lee, Rick Saylor, Daniel Tong, Tianfeng Chai, Fantine Ngan Yunsoo Choi, Hyun Kim		**CMAQ development, adaptation of AQ simulations for AQF**
Roland Draxler, Glenn Rolph, Ariel Stein		**HYSPLIT adaptations**
NESDIS/STAR	***Shobha Kondragunta, Jian Zeng***	***Smoke Verification product development***
NESDIS/OSDPD	***Matt Seybold, Mark Ruminski***	***HMS product integration with smoke forecast tool***
EPA/OAQPS ***partners:***		
Chet Wayland, Phil Dickerson, Scott Jackson, Brad Johns		***AIRNow development, coordination with NAQFC***

*** Guest Contributors**

Operational AQ forecast guidance

www.weather.gov/aq

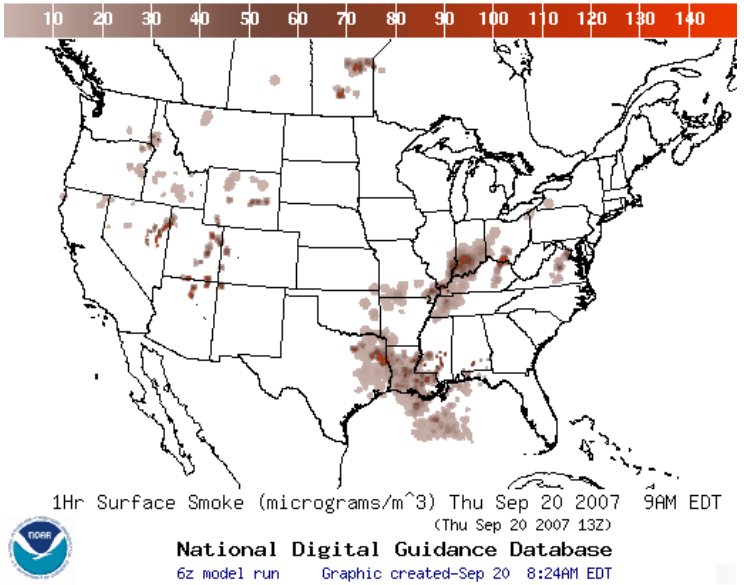


CONUS Ozone

Expansion Implemented September, 2007

Smoke Products

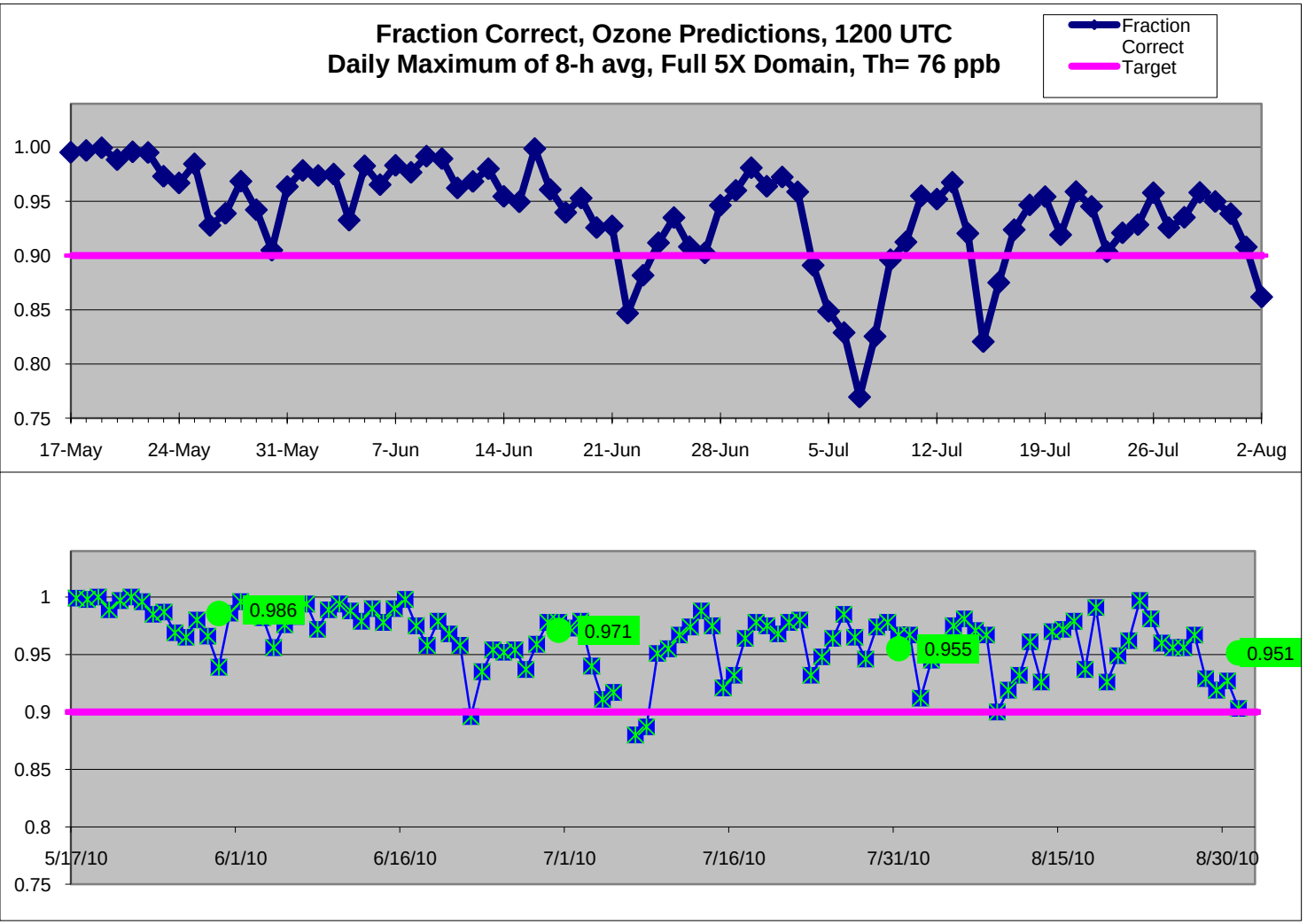
Implemented March, 2007



Further information: www.nws.noaa.gov/ost/air_quality

Appendix

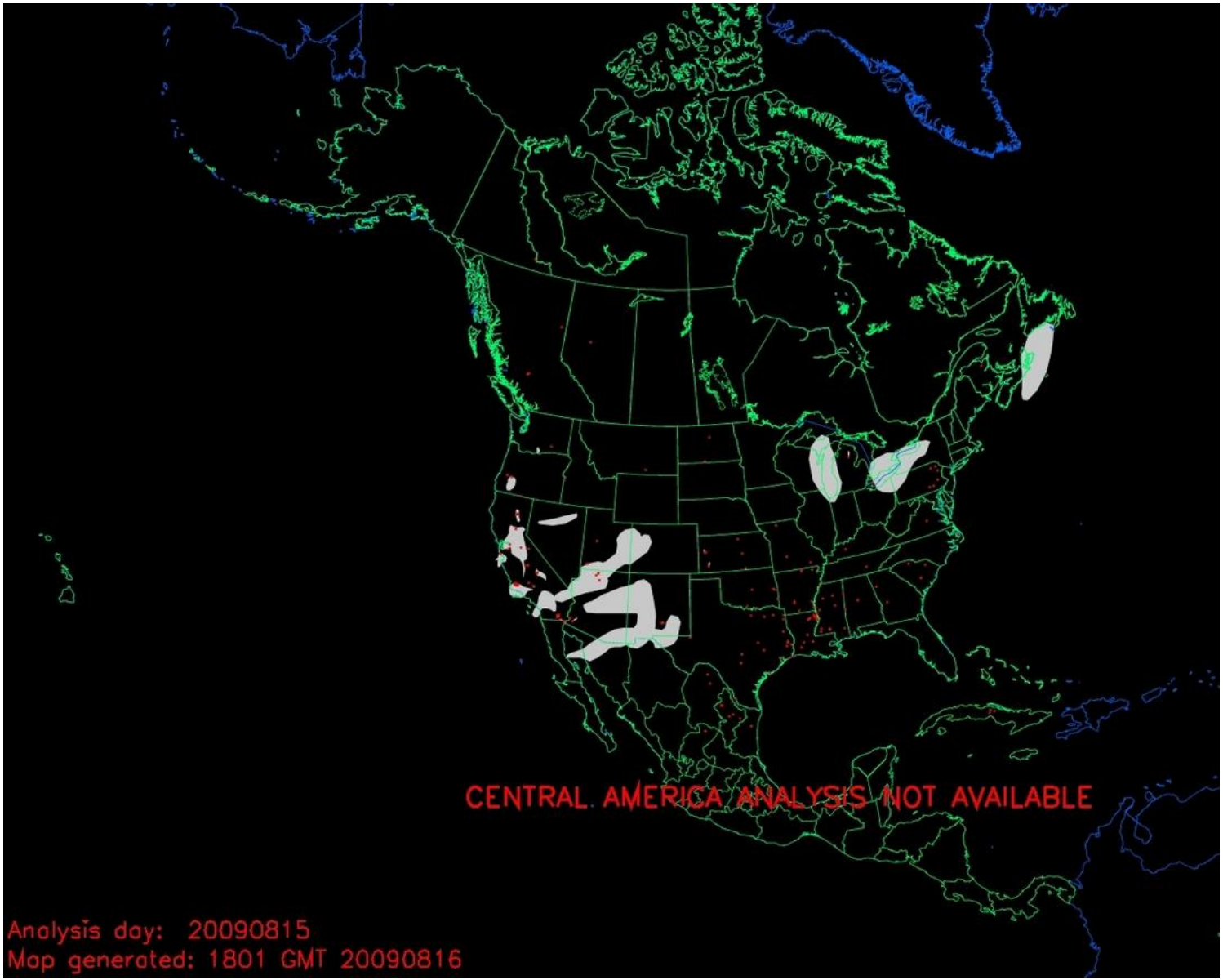
Real-time Testing, Summer 2010:
Experimental vs Operational O_3 at 76 ppb



Experimental CB05-based

Operational CBIV-based

Experimental vs. Operational, 76 ppb:
FC decreases in exptl predictions



HMS smoke analysis for August 15, 2009

Smoke Forecast Tool:
What is it?

Overview

- Passive transport/dispersion computed with HYSPLIT & WRF-NAM (or GFS, OCONUS). 24-hr spin-up, 48

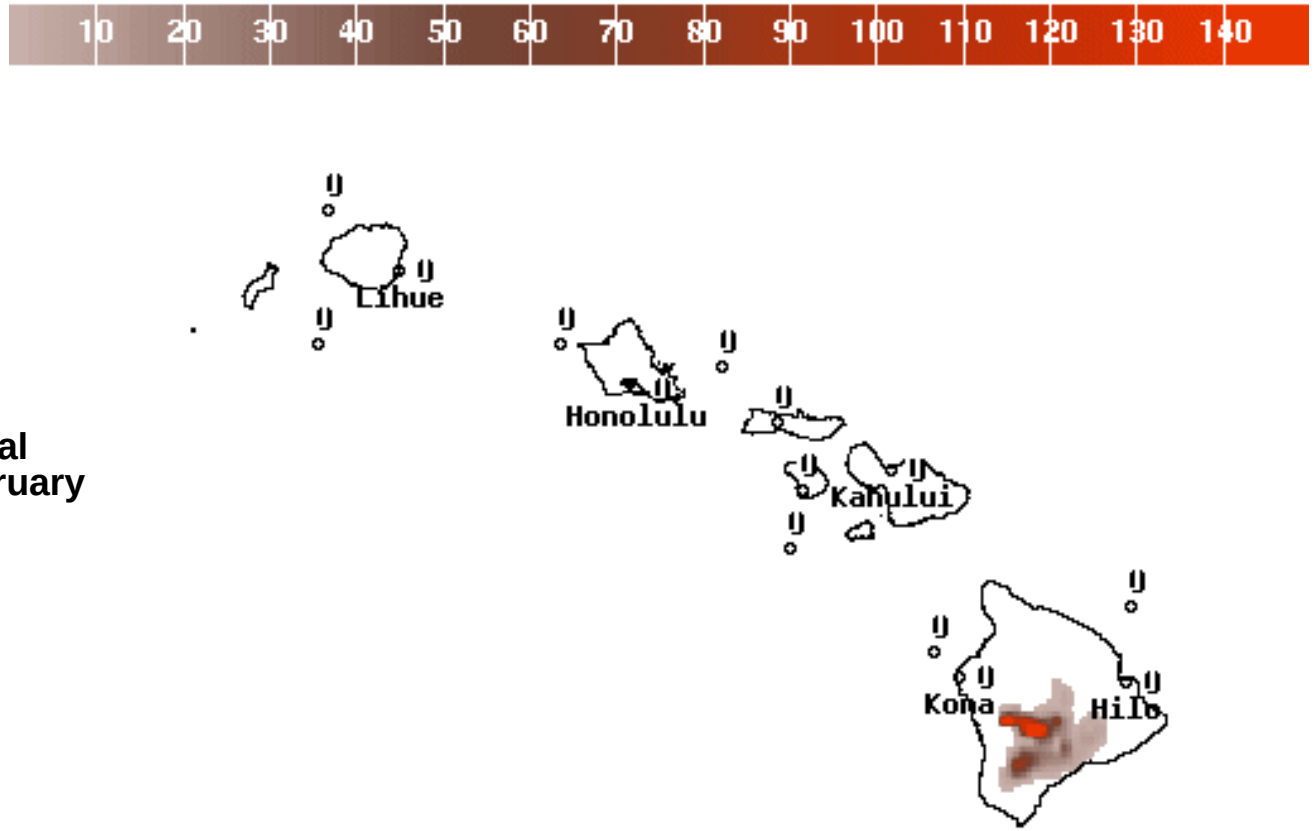
Continuing Science Upgrades
Improvements to the expanding NAQFC

Continuing R&D required

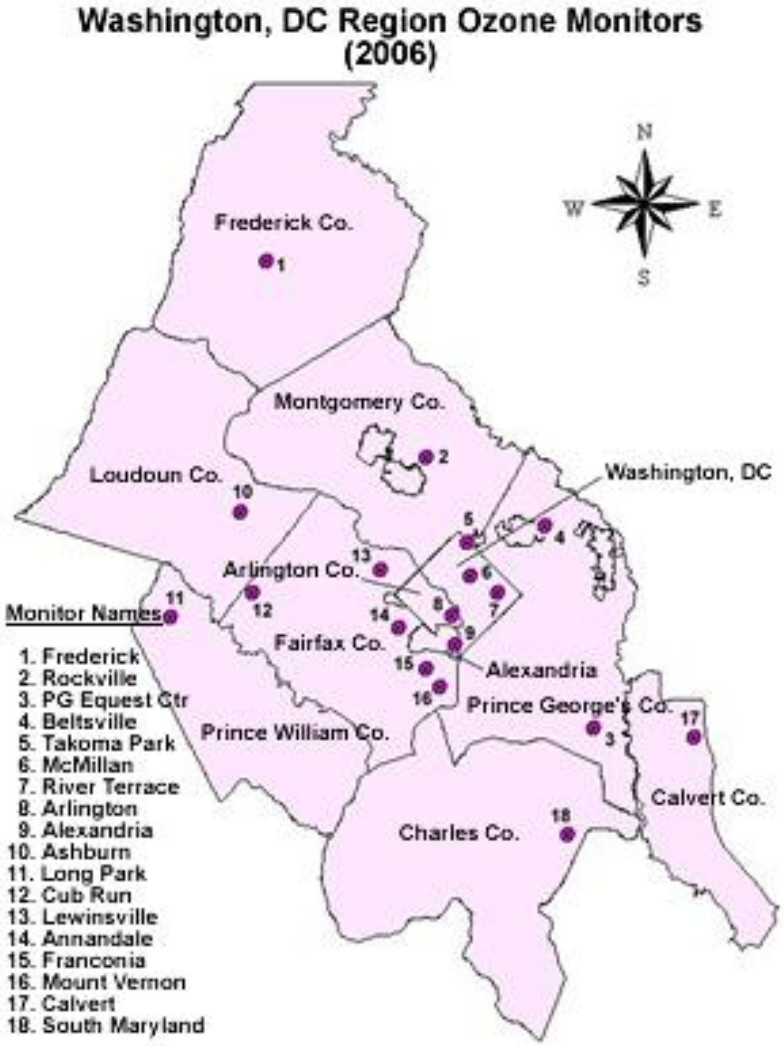
- OAR and EPA working actively with NWS to provide prototype capabilities for pre-operational development, testing experimental production, and implementation

Testing of HI smoke predictions

Operational since February 2010



Case Study: July 4-6th, 2010 Washington, DC



	July 4th, 2010	July 5th, 2010	July 6, 2010
Ozone prediction			
Verification (max level recorded)	86 ppb	82 ppb	90 ppb